APPENDIX J

CRATER ANALYSIS AND REPORTING

J-1. CRATER ANALYSIS TEAM

Although greater reliance should be placed on reports from trained teams, all personnel should know how to analyze craters and make the proper report. Since crater analysis teams are not authorized by TOE, each unit (including units normally located in rear areas) should select and train at least one team of two or three members. To adequately support their maneuver unit, fire support personnel must know how to analyze and report crater information.

J-2. EQUIPMENT

Three elements—direction, dimensions, and curvature—must be measured for crater analysis. The equipment used by the crater analysis team should consist of the following items:

- Declinated aiming circle (or M2 compass), stakes, and communications wire used to obtain the direction from the crater to the weapon that fired the projectile.
- A curvature template (Figure J-1) to measure the curvature of the fragment to determine the caliber of the shell. The template can be constructed of heavy cardboard, acetate, wood, or other appropriate material.
- Defense Intelligence Agency Projectile Fragment Identification Guide (DST-1160G-029-85) for measuring fragment dimensions.

J-3. SHELL CRATER ANALYSIS

a. The projectiles direction of flight can be determined with reasonable accuracy from its crater of ricochet furrow. By accurately locating the crater and determining the direction of flight, it is possible to obtain the azimuth of a ray that will pass through or near the enemy position. While it is possible to determine the direction to a battery from one crater or ricochet furrow, the battery may be located by plotting the intersection of the average azimuths from at least three widely separated groups of craters.

b. In crater analysis, differences in angle of fall, projectile burst patterns, directions of flight, and time fuze settings will help to distinguish between enemy batteries firing on a given area.

> **Note:** Refer to FM 3-100 for guidance on friendly troop safety from the effects of craters contaminated with chemical agents. Refer to STANAG 2002 in FM 3-100 for guidance in marking craters containing chemical, biological, or radiological contamination.

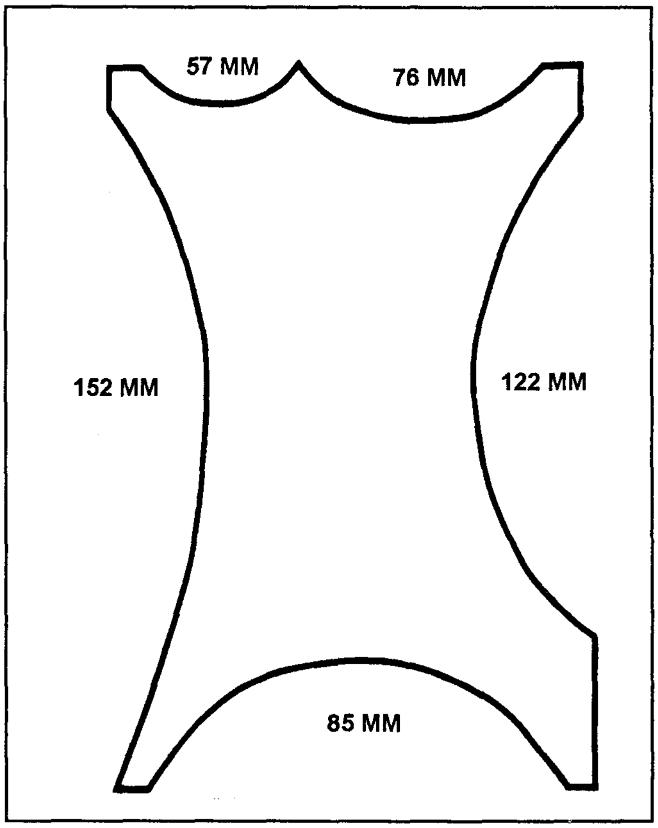


Figure J-1. **Curvature template**

J-4. VALUE OF ANALYSIS

By analyzing shell craters, it is possible to do the following:

- Verify as confined locations, suspected locations that have been obtained by other means.
- Confirm the presence of enemy artillery and obtain an approximate direction to it.
- Detect the presence of new types of enemy weapons, new calibers, or new ammunition manufacturing methods.

J-5. INSPECTION OF SHELLED AREAS

Shelled areas are inspected as soon as possible. Craters that are exposed to the elements or are abused by personnel deteriorate rapidly thereby losing their value as a source of information.

J-6. SURVEY OF CRATER LOCATION

Areas must be located accurately enough for plotting on charts, maps, or aerial photographs. Deliberate survey is not essential; hasty survey techniques or map spotting usually will suffice. Direction can be determined by use of an aiming circle or a compass.

J-7. DETERMINATION OF DIRECTION

a. Pattern. A clear pattern produced on the ground by the detonating shell indicates the direction from which the shell came.

b. Factors Affecting Pattern. Because of terrain irregularities and soil conditions, typical shell crater patterns are the exception, not the rule. Side spray marks are a principal part of the pattern caused by fragmentation. There is much less effect from nose spray. Base spray is negligible from gun and howitzer projectiles but is appreciable from mortars. The width, angle, and density of the side spray pattern vary with the projectile, the angle of impact, the type of fuze, terminal velocity of the projectile, and soil composition. In determining direction, the following are considered:

- The effect of stones, vegetation, stumps, and roots in the path of the projectiles.
- Variations in density and type of soil.
- The slope of the terrain at the point of impact.

From any group, only the most clearly defined and typical craters are used.

c. Marks on Vegetation and Other Objects. The direction from which a round was fired is often indicated by the marks made as it passes through trees, snow, and walls. The possible deflection of the shell upon impact with these objects must be considered. Evidence of such deflection should not be overlooked.

d. Drift and Wind Effects. Drift and lateral wind effects do not materially change the direction of the axis of the shell during flight.

e. Ricochet Furrows. Often when an artillery round with a delay fuze is fired at low angle, it bounces or ricochets from the surface of the earth. In doing so, it creates a groove, called a ricochet furrow, which is an extension of the plane of fire. Care must be taken, however, to determine that the shell was not deflected before or while making the furrow.

J-8. CRATER ANALYSIS

The first step in crater analysis is to locate a usable crater for determining the direction to the hostile weapon. The crater should be clearly defined on the ground and should be reasonably fresh. Since the crater is the beginning point for plotting the direction to the enemy weapon, the grid coordinates of the crater should be determined as an eight-digit grid, or as precisely as time and method used will allow. The direction to the firing weapon must be determined by one of the methods described in the following paragraphs. Shell fragments and fuzes must be collected for use in identifying the type, caliber, and country that manufactured the weapon and/or projectile.

J-9. LOW-ANGLE FUZE QUICK CRATERS (ARTILLERY)

The detonation of a projectile causes an inner crater. The burst and momentum of the shell carry the effect forward and to the sides, forming an arrow which points to the rear (toward the weapon from which the round was fired). The fuze continues along the line of flight, creating a fuze furrow. There are two methods of obtaining a direction to a hostile weapon from this type of crater. The best results are obtained by determining a mean, or average, of several directions obtained by using both methods.

a. Fuze Furrow and Center-of-Crater Method. In this method, stakes are placed in the center of crater and in the fuze furrow. Then the direction is measured to the hostile weapon. (See Figure J-2.) A variation of this method is to place a stake where the shell entered the ground instead of the fuze furrow and determine the direction in the same manner. This method is rarely possible, however, since indications of the point of entry are usually destroyed by the explosion of the shell. The five steps of this method are as follows:

- Place a stake in the center of the crater.
- Place a second stake in the fuze furrow at the point where the fuze was blown forward to the front of the crater.
- Setup direction-measuring instrument in line with the stakes and away from fragments.
- Orient the instrument.
- Measure the direction to the hostile weapon.

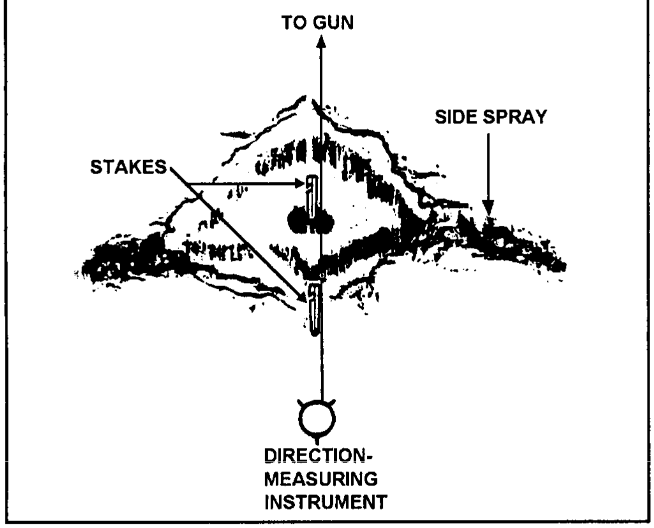


Figure J-2. **Fuze furrow and center-of-crater method**

b. Side-Spray Method. Another method to measure the direction to a hostile weapon is to bisect the angle formed by the lines of side spray. (Figure J-3.) The seven steps in the side spray method are as follows:

- Place a stake in the center of the crater.
- Place two stakes, one at the end of each line of side spray, equidistant from the center stake.
- Hold a length of communications wire (or another appropriate field-expedient means) to each side spray stake, and strike an arc forward of the fuze furrow.
- Place a stake where these arcs intersect.
- Set up a direction-measuring instrument in line with the center stake and the stake at the intersection of the arcs.
- Orient the instrument.
- Measure the direction to the firing weapon.

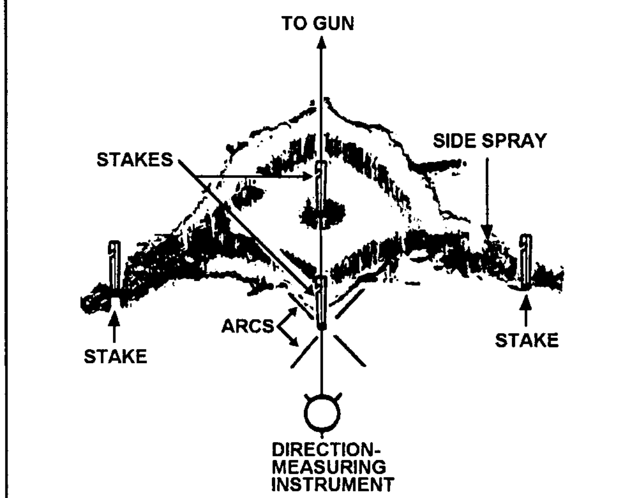


Figure J-3. **Side-spray method**

J-10. LOW-ANGLE FUZE DELAY CRATERS (ARTILLERY)

There are two types of fuze delay craters: ricochet and mine action.

a. Ricochet. The projectile enters the ground in line following the trajectory and continues in a straight line for a few feet, causing a ricochet furrow. The projectile normally deflects upward and, at the same time, it changes direction usually to the right as the result of the spin, or rotation, of the projectile. The effect of the airburst can be noted on the ground. Directions obtained from ricochet craters are considered to be the most reliable. The five steps to determine direction from a ricochet furrow (Figure J-4) are as follows:

- Clean out the furrow.
- Place stakes at each end of a usable straight section of the furrow.
- Set up a direction-measuring instrument in line with the stakes and away from fragments.
- Orient the instrument.
- Measure the direction to the weapon.

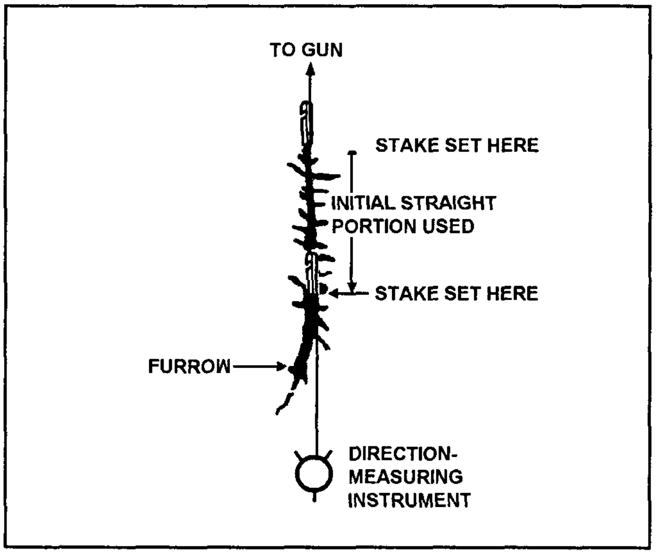


Figure J-4. **Ricochet furrow method**

b. Mine Action. This occurs when a shell burst beneath the ground. Occasionally, such a burst will leave a furrow which can be analyzed in the same manner as the ricochet furrow. A mine action crater which does not have furrow cannot be used to determine the direction to the weapon.

J-11. HIGH-ANGLE SHELL CRATERS (MORTARS)

In a typical mortar crater, the turf at the forward edge (the direction away from the hostile mortar) is undercut. The rear edge of the crater is shorn of vegetation and grooved by splinters. When fresh, the crater is covered with loose earth, which must be carefully removed to disclose the firm, burnt inner crater. The ground surrounding the crater is streaked by splinter grooves that radiate from the point of detonation. The ends of the splinter grooves on the rearward side are on an approximately straight line. This line is perpendicular to the line of flight if the crater is on level ground or on a slope with contours perpendicular to the plane of fire. A fuze tunnel is caused by the fuze burying itself at the bottom of the inner crater in front of the point of detonation. Three methods may be used to determine direction from a mortar shell crater-the main axis, splinter groove, and fuze tunnel methods.

a. Main Axis Method. The four steps to determine direction by the main axis method (Figure J-5) areas follows:

- Lay a stake along the main axis of the crater, dividing the crater into symmetrical halves. The stake points in the direction of the mortar.
- Set up a direction-measuring instrument in line with the stake and away from fragments.
- Orient the instrument.
- Measure the direction to the weapon.

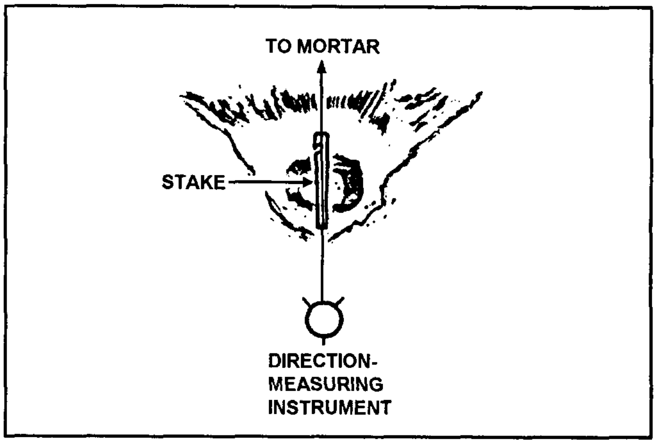


Figure J-5. **Main axis method**

b. Splinter Groove Method. The five steps to determine direction by the splinter groove method (Figure J-6) are as follows:

- Lay a stake along the ends of the splinter grooves that extend from the crater.
- Lay a second stake perpendicular to the first stake through the axis of the fuze tunnel.
- Set up a direction-measuring instrument in line with the second stake and away from fragments.
- Orient the instrument.
- Measure the direction to the weapon.

c. Fuze Tunnel Method. The four steps to determine direction by the fuze tunnel method (Figure J-7) are as follows:

- Place a stake in the fuze tunnel.
- Set up a direction-measuring instrument in line with the stake and away from fragments.
- Orient the instrument.
- Measure the direction to the weapon.

Note: If the angle of fall is too great (a 90° angle), the fuze tunnel method cannot be used.

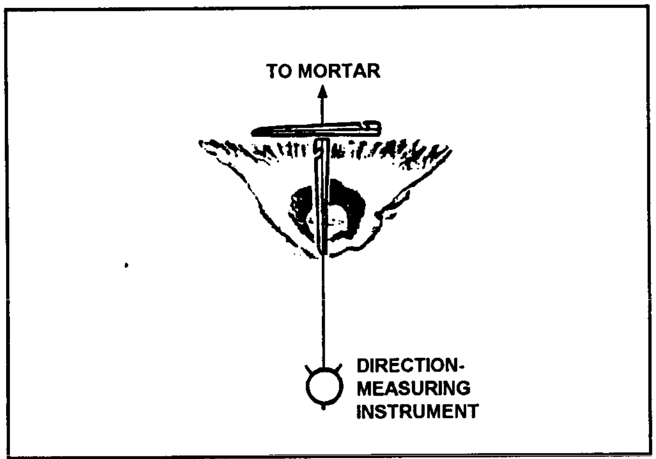


Figure J-6. **Splinter groove method**

J-12. ROCKET CRATERS

A crater resulting from a rocket impacting with a low or medium angle of fall is analyzed in the same manner as an artillery crater resulting from a projectile armed with fuze quick. However, if the rocket impacts with a high angle of fall, the crater is analyzed in the same manner as a crater resulting from a mortar round. The tail fins, rocket motor, body, and other parts of the rocket, may be used to determine the caliber and type of rocket fired.

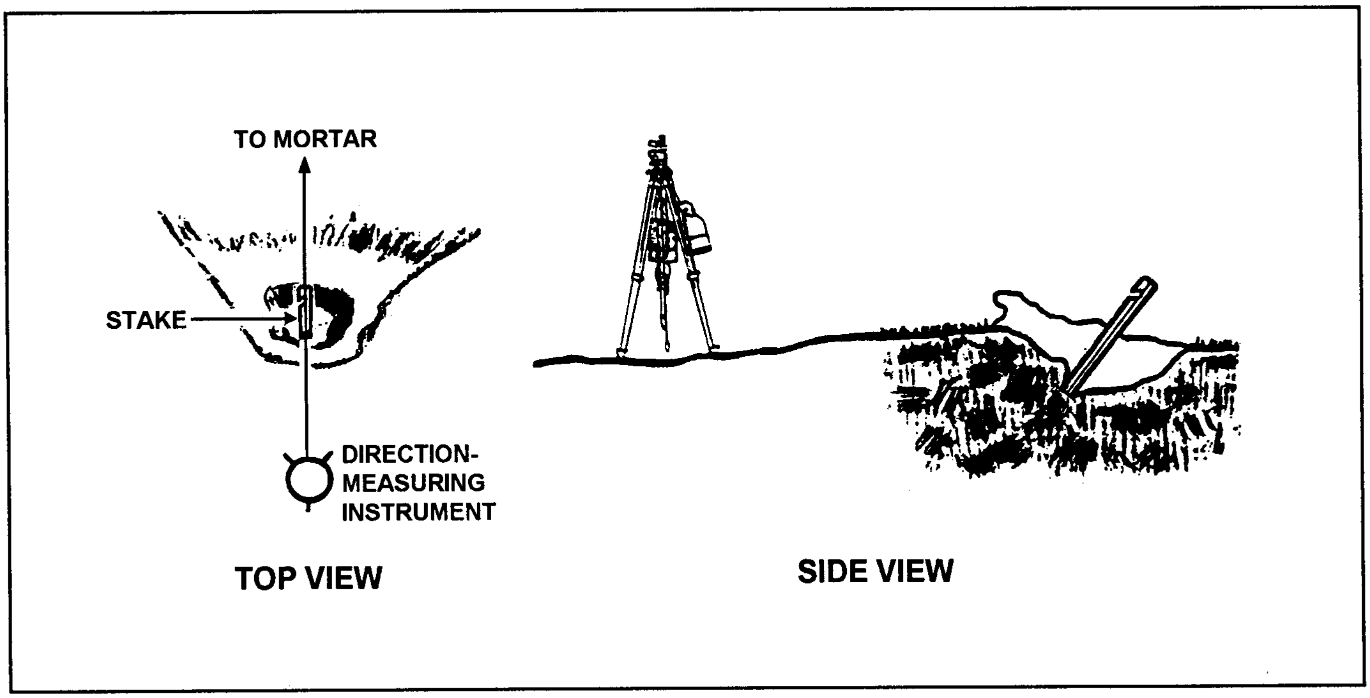


Figure J-7. **Fuze tunnel method**

J-13. SHELL FRAGMENT ANALYSIS

A weapon may be identified as to type and caliber from shell fragments found in the shell crater. Dimensions of the parts as well as of the complete shell, vary according to the caliber and type of shell. A typical shell is shown in Figure J-8.

a. Duds and Low-Order Bursts. The most logical means of identifying the caliber of a projectile is to inspect a dud of that caliber. However, since a dud may not always be available (or, if available, may be too dangerous to handle), a low-order burst is the next best means of identification. When the explosive filler is incompletely detonated, a low-order burst occurs and large shell fragments result. Such large pieces can be used to identify thread count, curvature, wall thickness, and other information not obtainable on smaller fragments. (See Figures J-1 and J-8.)

b. High-Order Burst. A high-order burst normally results in small, deformed fragments. These fragments are useless for identification purposes unless they include a section of either the rotating band or the rotating band seat. Fragments of either of these sections positively identify the shell, since each shell has its own distinctive rotating band markings.

c. Rotating Bands and Band Seats. (See Figure J-9.) A shell may be identified as to caliber, type and nation of origin from the following:

- Pattern or rifling imprints.
- Width, number, and size of rotating bands.
- Dimensions and pattern of keying or knurling on the band seat.
- Dimensions and pattern of keying and knurling impressed on the rotating band.

> **Note**: Spin-stabilized artillery projectiles require a rotating band and band seat.

d. Tail Fins. A mortar may be identified from the tail tin (Figures J-9 and J-10). Often, tail fins are found in the fuze tunnel of the crater. A mortar that is not fin-stabilized may be identified from the pieces of the projectile on which the rifling is imprinted.

e. Fuzes. Since the same type of fuze may be used with several different calibers or types of projectiles, it is impossible to establish the type and caliber of a weapon by this means.

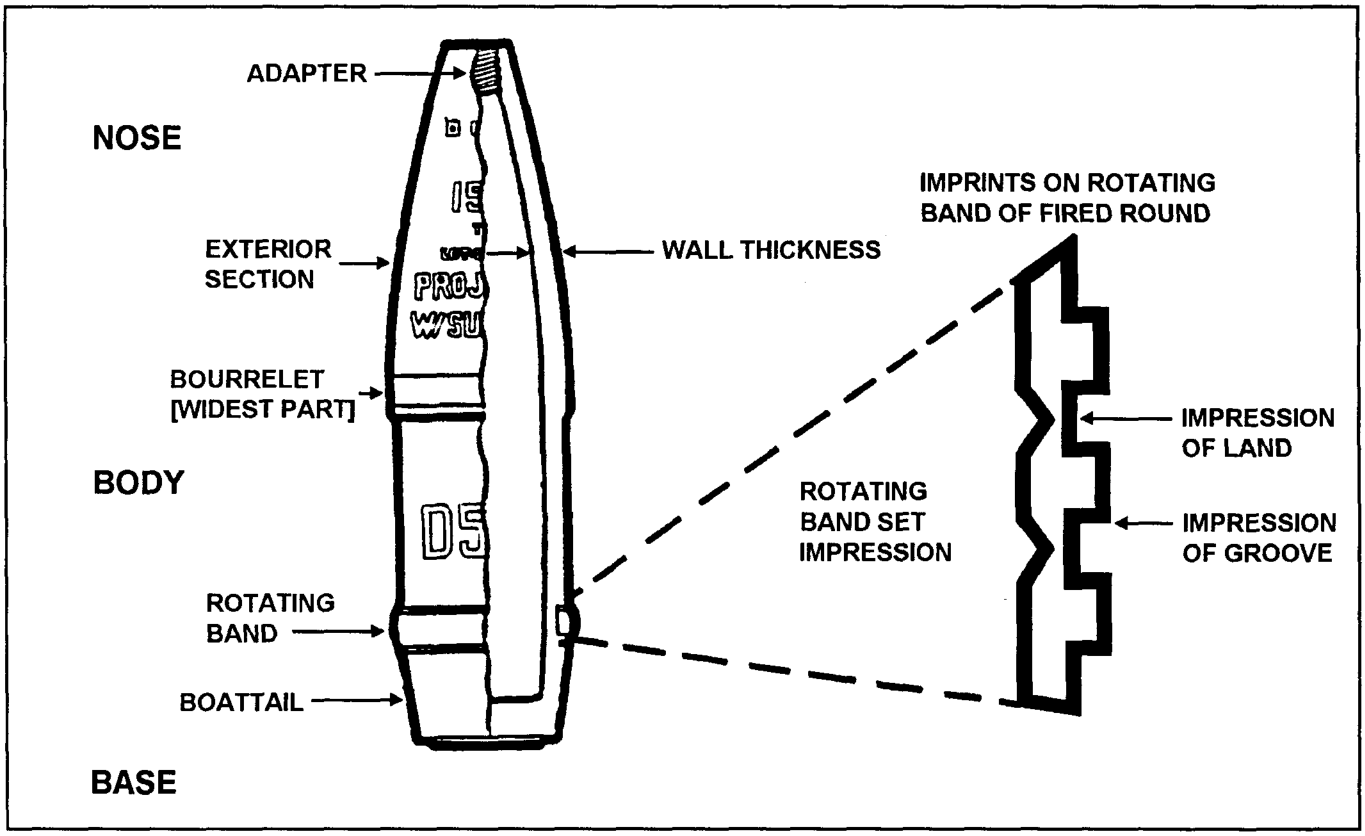


Figure J-8. **Typical shell**

Note: With the exception of the rotating bands and band seats or the tail fins, different types of shells may be identical in one dimension (such as wall thickness) but seldom will be alike in two or more dimensions. Therefore, it is necessary to obtain two or more measurements to make a positive identification.

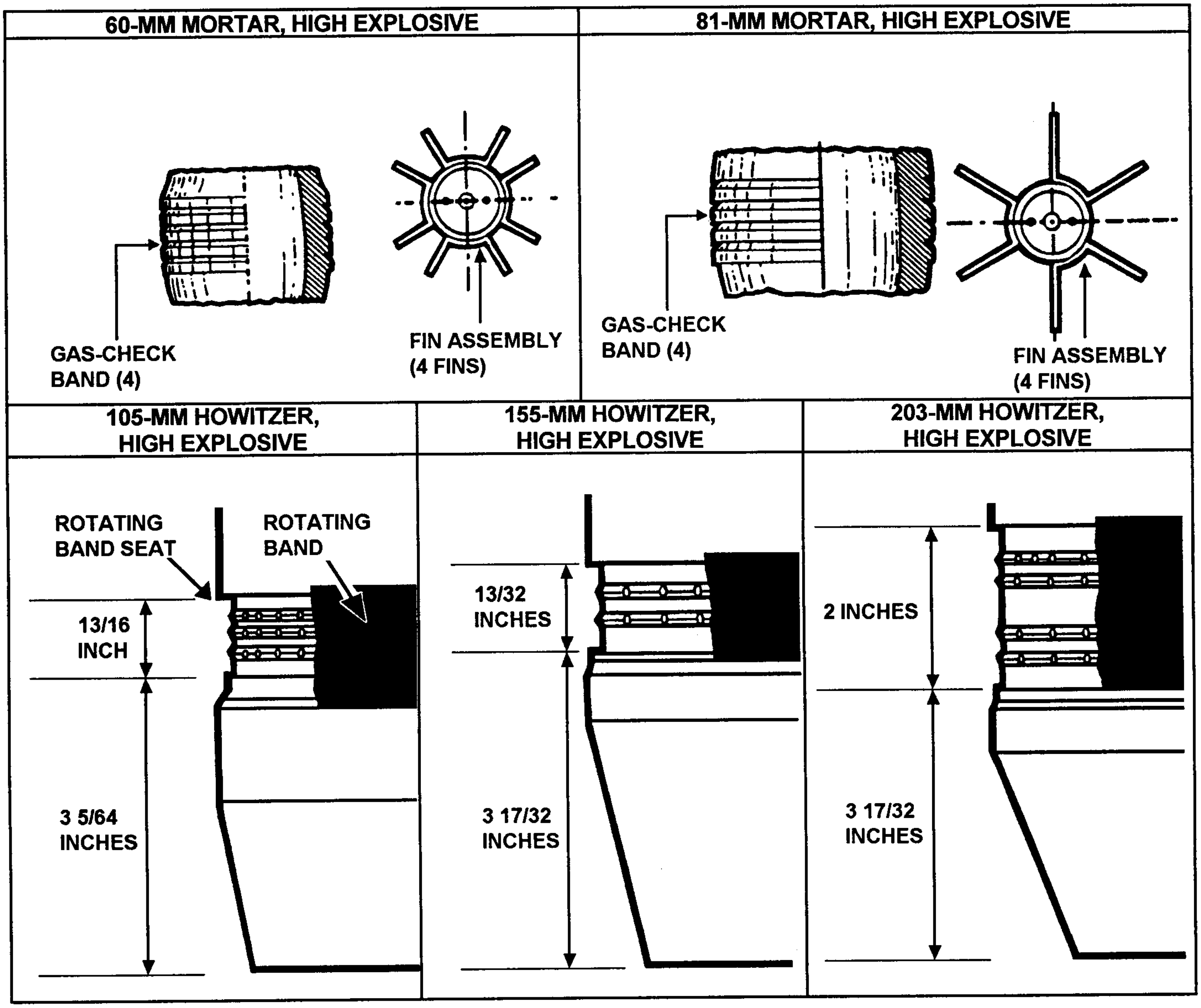


Figure J-9. **Shell fragment and tail identification, US ammunition**

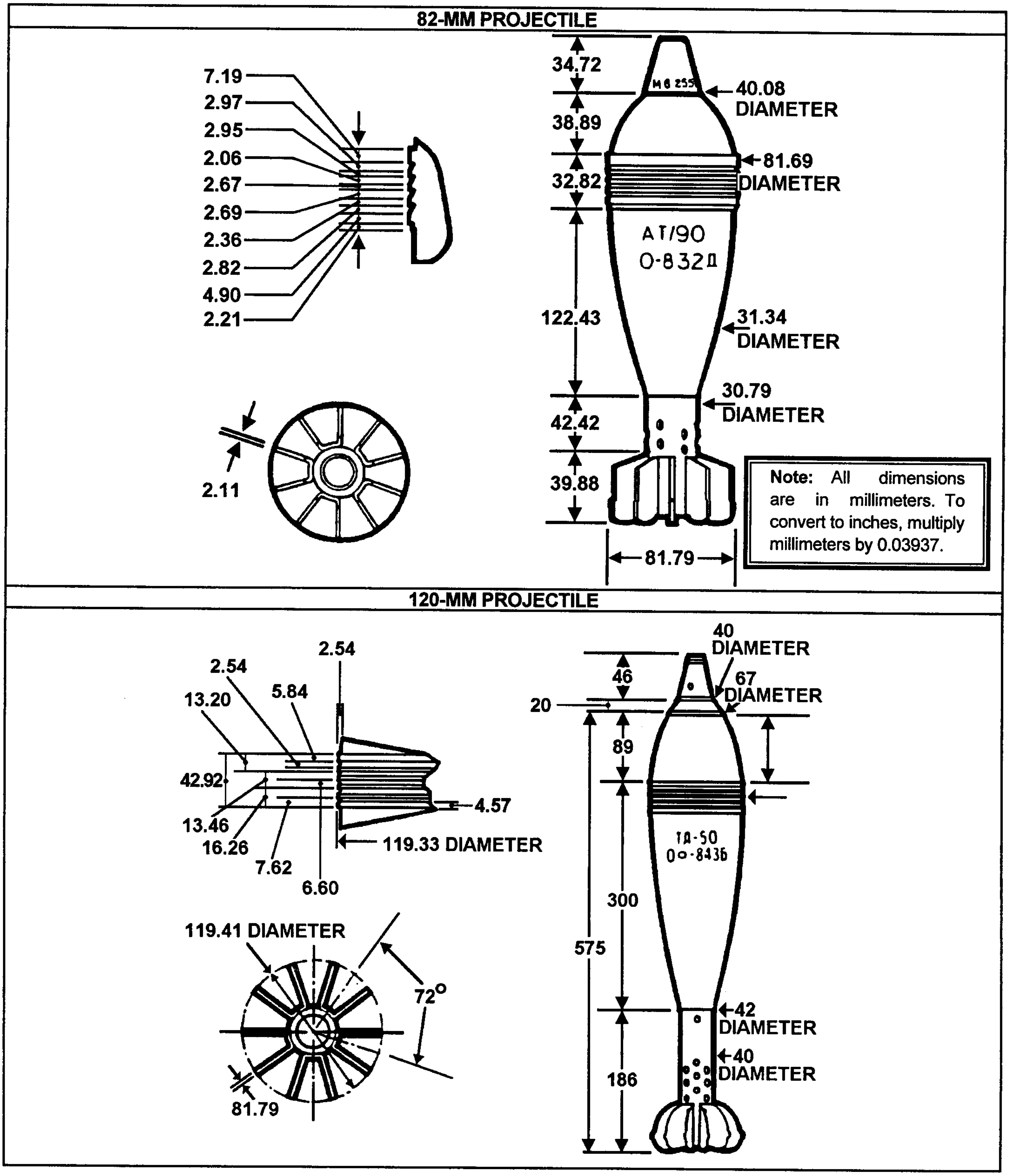
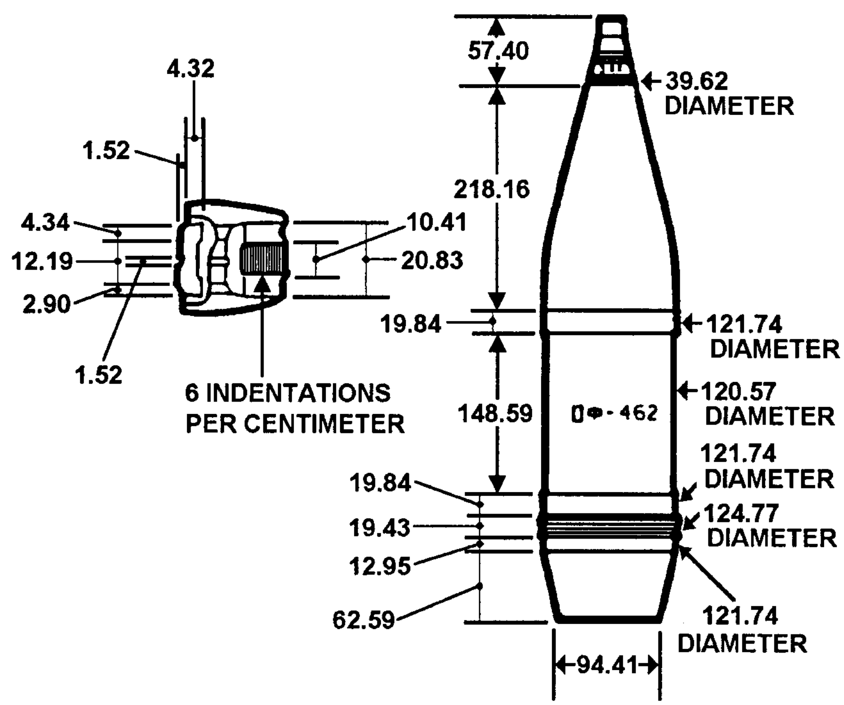


Figure J-10. **Other nations' ammunition**

122-MM PROJECTILE



152-MM PROJECTILE

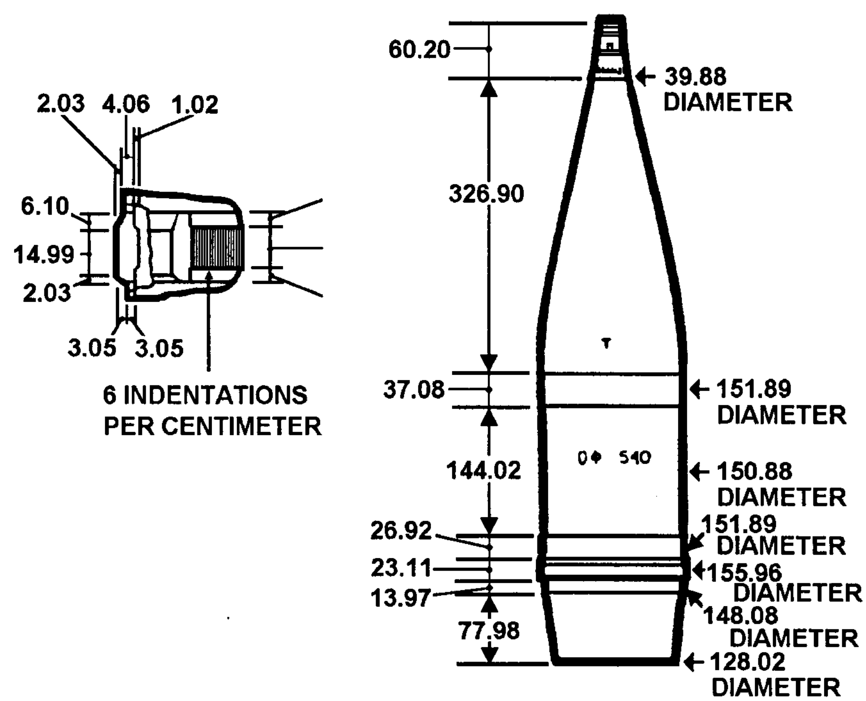


Figure J-10. **Other nations' ammunition (continued)**

J-14. SHELLING REPORTS

The division artillery (div arty) is responsible for counterfire. Therefore, bombing reports (BOMBREPs), shelling reports (SHELREPs), and mortar reports (MORTREPs) should be forwarded as quickly as possible to the div arty tactical operations center (TOC) through either fire direction or fire support channels. If a report is received by a DS battalion and that battalion decides to attack, the report of action taken and a damage assessment, if available, should be forwarded to the div arty TOC when the action is completed.

a. Contents. To provide a standard method of rendering reports on enemy bombing, shelling, and mortaring within the NATO forces operating on land, and the United States armed forces and certain other NATO armed forces, have concurred in the provisions of STANAG 2008. Refer to STANAG 2103 as implemented in FM 3-100 (in conjunction with STANAG 2008), for guidance in reporting the type of attack.

b. Artillery Counterfire Information Form. The information obtained from a crater should be forwarded by the most rapid means available—the ATI;SHR followed up with DA Form 2185-R (Artillery Counterfire Information) (ACIF) (Figure J-11). Regardless of how little information has been obtained, do not hesitate to forward it. Fragmentary or incomplete information (a radio or telephone report) is often valuable in supplementing or confirming existing information. This radio or telephone report may be followed by a written report (DA Form 2185-R).

> **Note**: A reproducible copy of DA Form 2185-R is located at the back of this manual.

c. Fragments. Any usable fragments obtained from crater analysis should be tagged (shoe tag) and sent to the battalion S2. As a minimum, the tag should indicate the following:

- The location of the hostile weapon.
- The direction to the hostile weapon.
- The date-time group of the shelling.
- Mortor, artillery, or rocket, if known.

EXAMPLE

The information in the following situation is illustrated on the completed DA Form 2185-R (Figure J-11). You are the executive officer of Battery A, 1st Battalion, 3d Field Artillery. Your cell sign is A3F22, which is located at grid 39288415. At 0545 hours, the enemy shelled your position for 2 minutes with a total of eight rounds of HE shells. The tempo and pattern of bursts suggest an enemy four-gun battery. Your battery commander believes that the enemy's intent was harassment. Your SHELREP team determined the direction to the enemy battery to be 4,810 mils. They also located a fragment which included a portion of the rotating band seat. The shell has been identified as an enemy 122-mm howitzer projectile.

The four blanks above SECTION I of DA Form 2185-R are not completed by the SHELREP team. They are filled in by the receiving agency, for example, the battalion S2 section.

Items B and K or SECTION I are encoded for security reasons. The current call sign or code name for the unit is used in item A. Item B is not applicable when this form is used for crater analysis.

SECTIONS II and III are completed by the target production section of the div arty TOC.

The information contained in a SHELREP is forwarded by the DS artillery S2 to the targeting cell at div arty. He plots (on a SHELREP overlay) the location of the crater and a line representing the direction measured to the weapon. He compares the information with that received from other sources and attempts to locate enemy weapons from the intersections of direction lines to weapons of the same caliber.

ARTILLERY COUNTERFIRE INFORMATION

(For use of this form, see FM 6-121; the proponent agency is TRADOC.)

RECEIVED BY	FROM	TIME	NUMBER

SECTION I - BOMREP, SHELREP, MORTREP, OR ROCKREP (Cross out items not applicable.)

UNIT OF ORIGIN (Current call sign address group or code name)	POSITION OF OBSERVER (Encode if HQ or important OP or if Column F gives info on loction)	DIRECTION (Grid bearing of FLASH, SOUND, or GROOVE of SHELL [state which] in mils unless otherwise stated). (Omit for aircraft)	TIME FROM	TIME TO	AREA BOMBED, SHELLED, OR MORTARED (Grid ref [in clear] or grid bearing to impact in mils and distance from observer in meters [encoded]) (Dimension of the area in meters) by (the radius) or (length and width)	NUMBER AND NATURE OF GUNS (Mortars, rocket launchers, aircraft, or other methods of delivery)	NATURE OF FIRE (Adjustment, fire for effect, or harassing) (May be omitted for aircraft)	NUMBER, TYPE, AND CALIBER (State whether measured or assumed) OF SHELLS, ROCKETS (or MISSILES), AND BOMBS	TIME OF FLASH-TO-BANG (Omit for aircraft)	DAMAGE (Encode if required)
F22	NA	4810m	0545	0547	39268415	4 / ARTY	H	8 / HE / 122	NA	NA
A	B	C	D	E	F	G	H	I	J	K

	SECTION II - LOCATION REPORT						SECTION III — COUNTERFIRE ACTION		
REMARKS	SERIAL NUMBER (Each location that is produced by a locating unit is given a serial number)	TARGET NUMBER (If the weapon or activity has previously been given a target number, it will be entered here)	POSITION OF TARGET (The grid reference or grid bearing and distance of the located weapon or activity)	ACCURACY (The accuracy to which the weapon was located. CEP in meters and the means of location if possible)	TIME OF LOCATION (Actual time the location was made)	TARGET DESCRIPTION (Dimensions if possible): 1. Radius of target 2. Target length and width in meters	TIME FIRED (Against hostile target)	FIRED BY	NUMBER OF ROUNDS, TYPE OF FUZE, AND PROJECTILES
L	M	N	P	Q	R	S	T	U	V

DA FORM 2185-R, 1 APR 90 (Conforms with STANAG 2008) Edition of 1 May 78 is obsolete.

Figure J-11. **Completed DA Form 2185-R**